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SEMI-ANNUAL STATUS REPORT

SUPERSONIC BURNING IN SEPARATED FLOW REGIONS

for

Langley Research Center

National Aeronautics and Space Administration

Hampton, Virginia

from

Aeronautical Engineering Department
Wichita State University
Wichita, Kansas

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INSTRUMENTATION

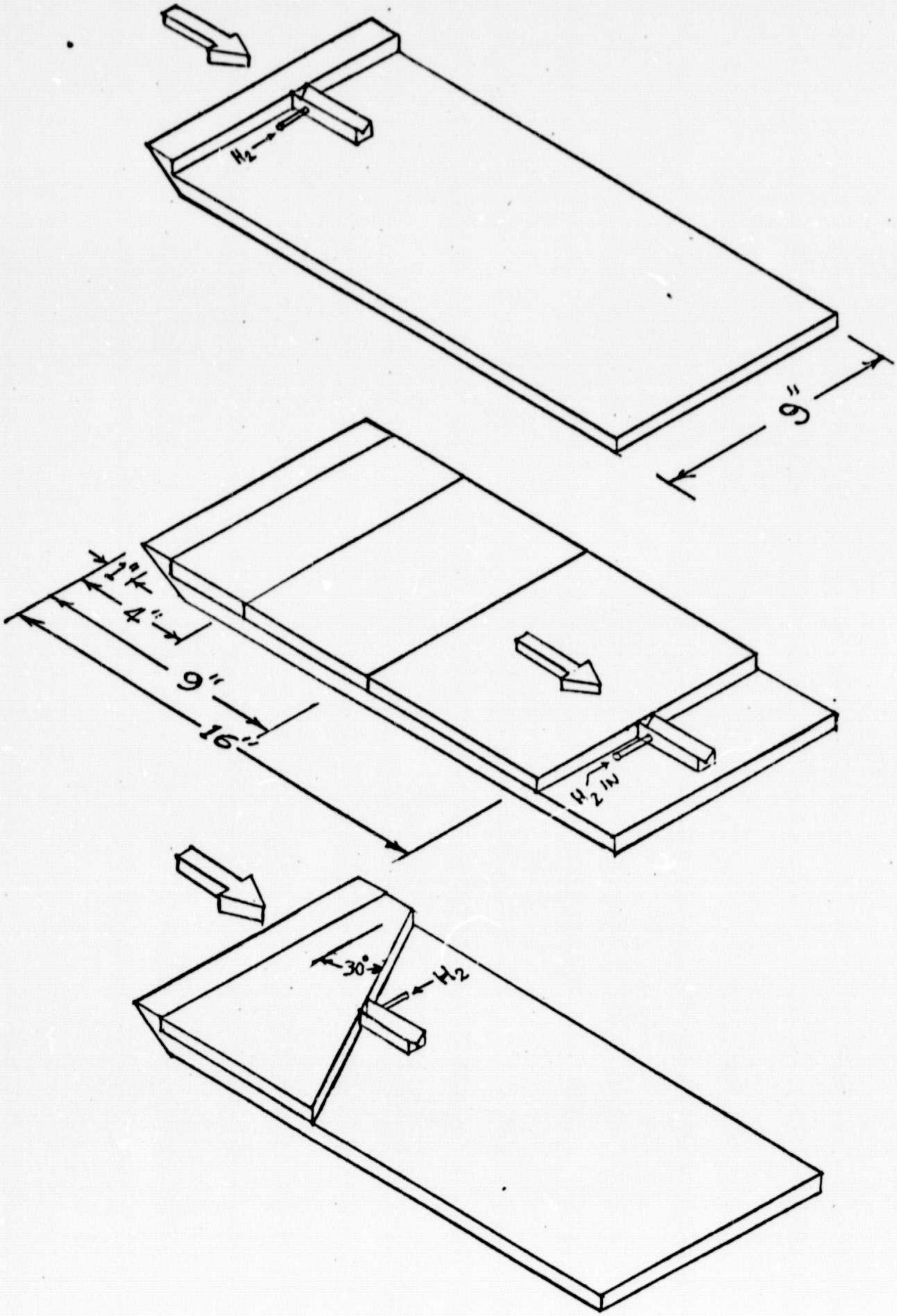
Reliable temperature measurement in the gases in the base region is a major objective. This is difficult because of the high temperature, the presence of free hydrogen atoms and the ionized state of the gas. In addition, the trough geometry almost precludes optical "look through" techniques. The high temperature requires platinum alloy thermocouples, but platinum combines with hydrogen at high temperatures forming alloys on the surface that change the thermo-electric characteristics. Thus, a protective coating or "sheath" is needed. The ionized gases tend to produce electric signals in a thermocouple, so the sheath should serve as an electric insulator. Our small geometry and short run times further require very small thermocouples.

A number of telephone conversations were conducted to seek a supply of such thermocouples, or -failing that- to gain from the experience of those who make such devices for their own use. Personnel at the University of Wisconsin, General Electric Labs, NASA/Lewis, Pratt & Whitney and the National Bureau of Standards in Washington were contacted. Dr. Ray Dils of N.B.S., Washington, was able to give a quite specific design and manufacturing method, but none of the organizations could supply the thermocouples or suggest a source of supply. We then went about making these ourselves, using capacitive discharge to butt weld 3 mil wires, and aluminum oxide as the sheath. The thermocouples are under construction and test now. A new read-out instrument for the thermocouples was purchased (not on contract funds).

MODEL MAKING

Trough tests are planned for step sizes of 6.35, 2.54, 0.63, and 0.25 cm. The largest one had been made previously. The two smaller sizes presented new design problems. A multi-position back step plate was constructed for use with these small models. The plate is placed in the center of the 23x23 cm. supersonic wind tunnel, and the trough models rest on the surface. Insert plates provide variable upstream plate length to study the effect of boundary layer thickness at the separation corner. The plates also provide a method of skewing the corner line. See the sketches on the next page.

Currently, tests are being run at Mach = 2 for the 0.63 cm. trough, and we have achieved reliable ignition and stable burning. Very small flow metering orifices have been made for hydrogen measurement.

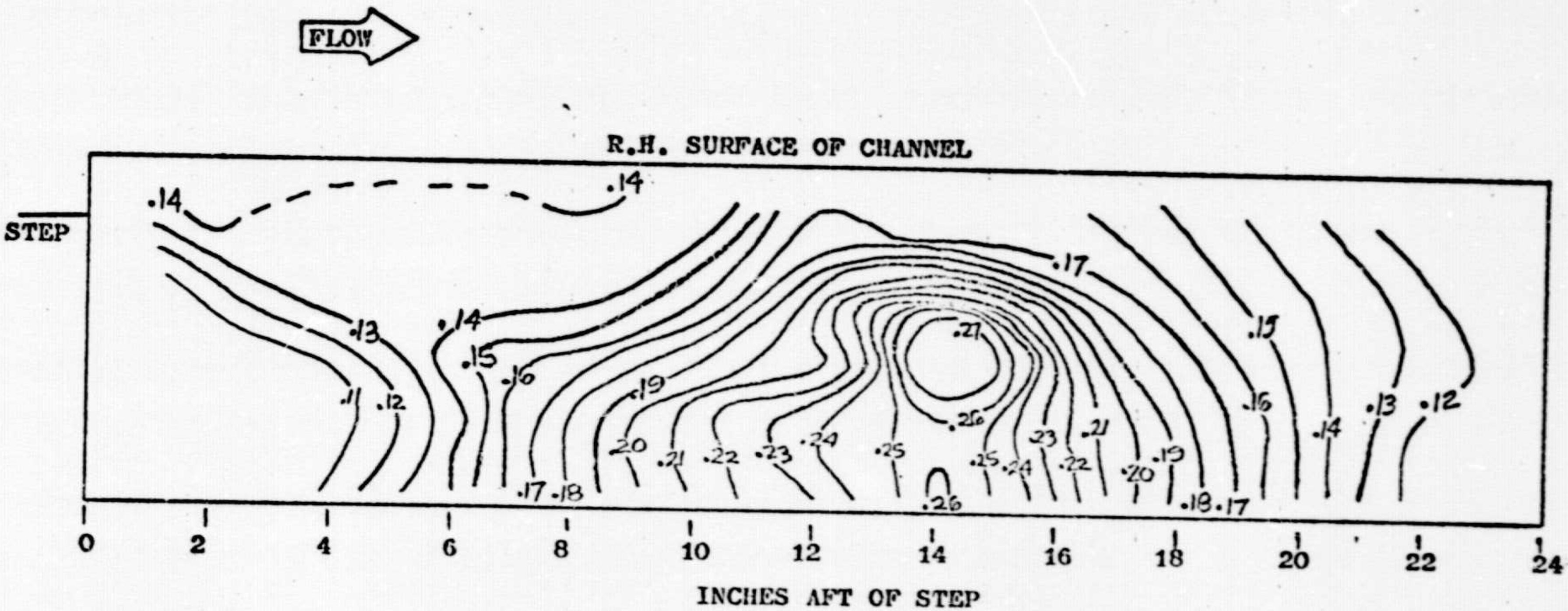


H_2
9"
1"
4"
9"
16"
H_2 IN
30°
H_2

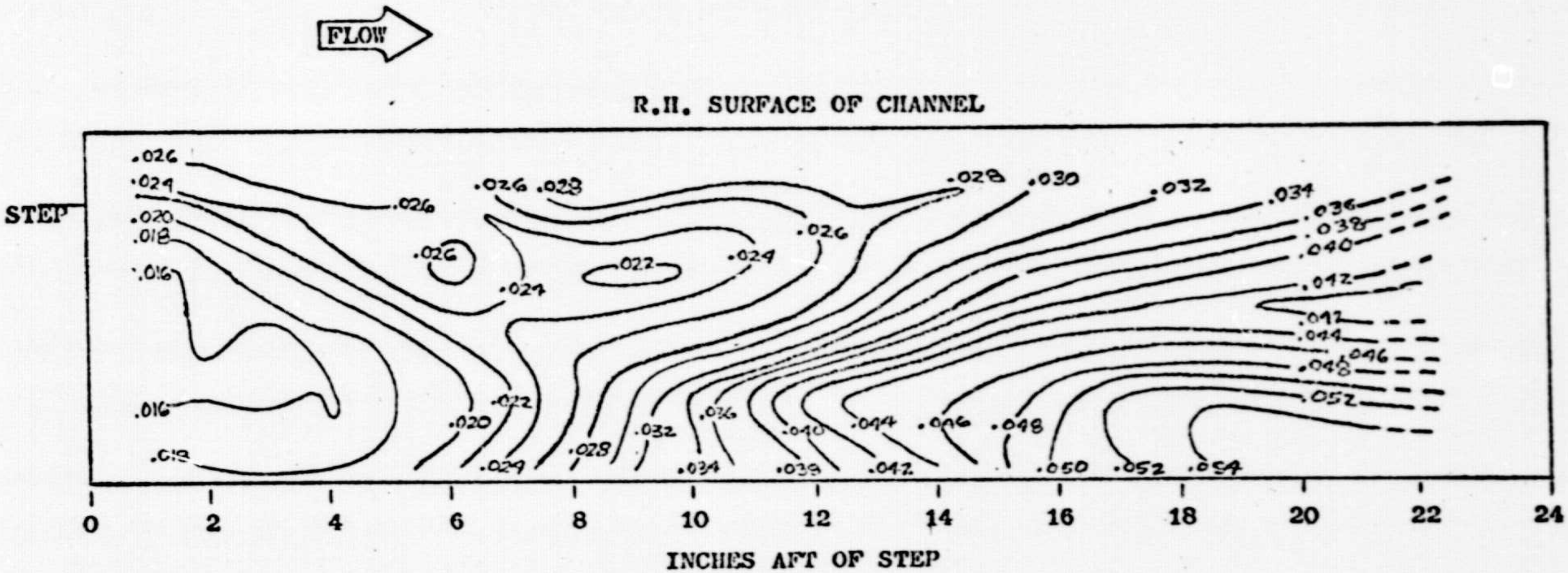
FLOW PATTERN STUDIES

While construction continued as outlined above, tests were made with the 6.35 cm. trough to learn more about the details of the complex flow resulting when a shear layer reattaches in a corner. Oil streak photos of both supersonic (M=2) and subsonic flows were made. Static pressures on the side walls and pitot maps of the flow at various streamwise stations were made to clarify the flow patterns. Seven plots of these are attached. Intelligent design of good mixing slots for flame holding purposes will ultimately depend on an understanding of the flow phenomena, particularly the vortex behavior. Enclosed are photograph of sidewall oil streaks for M = 2 flow, and some static and pitot pressure results @ M = 3. Clearly, the flow is quite complex.

CHANNEL AT 0° TILT

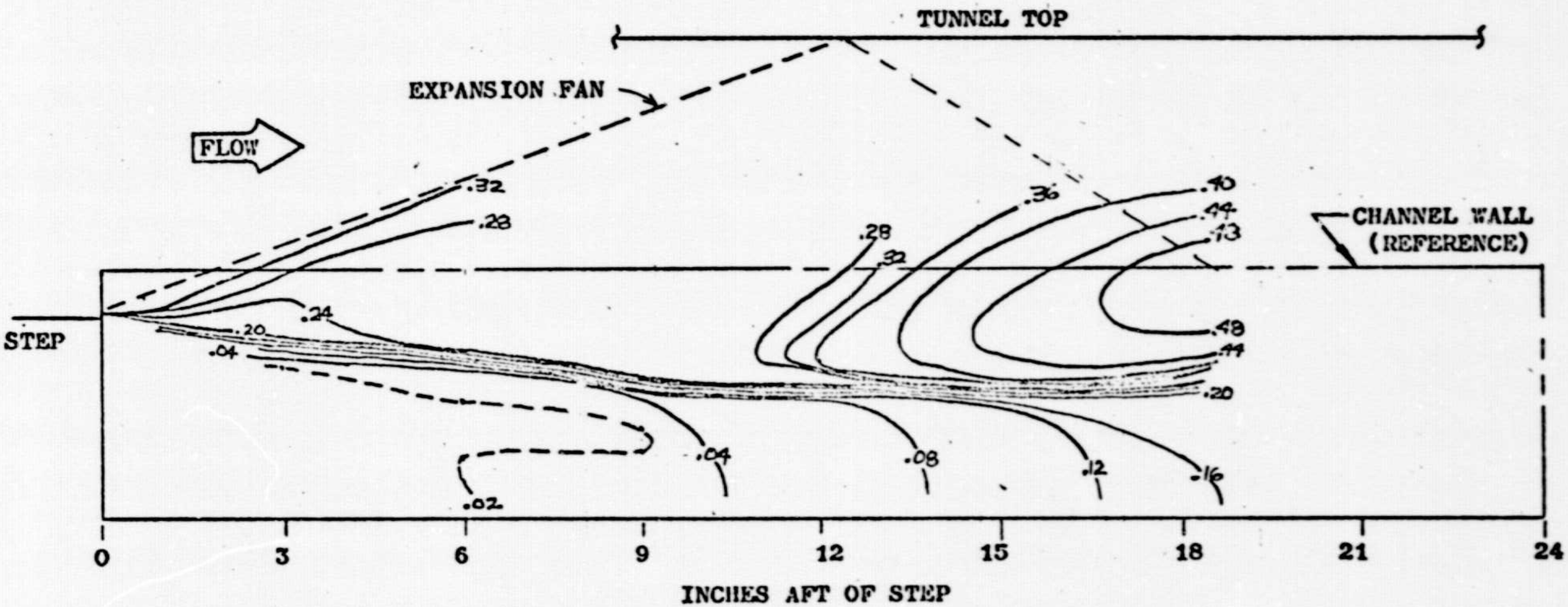


P/P_0 SURFACE DISTRIBUTION - MACH 2.05 - 0° TILT



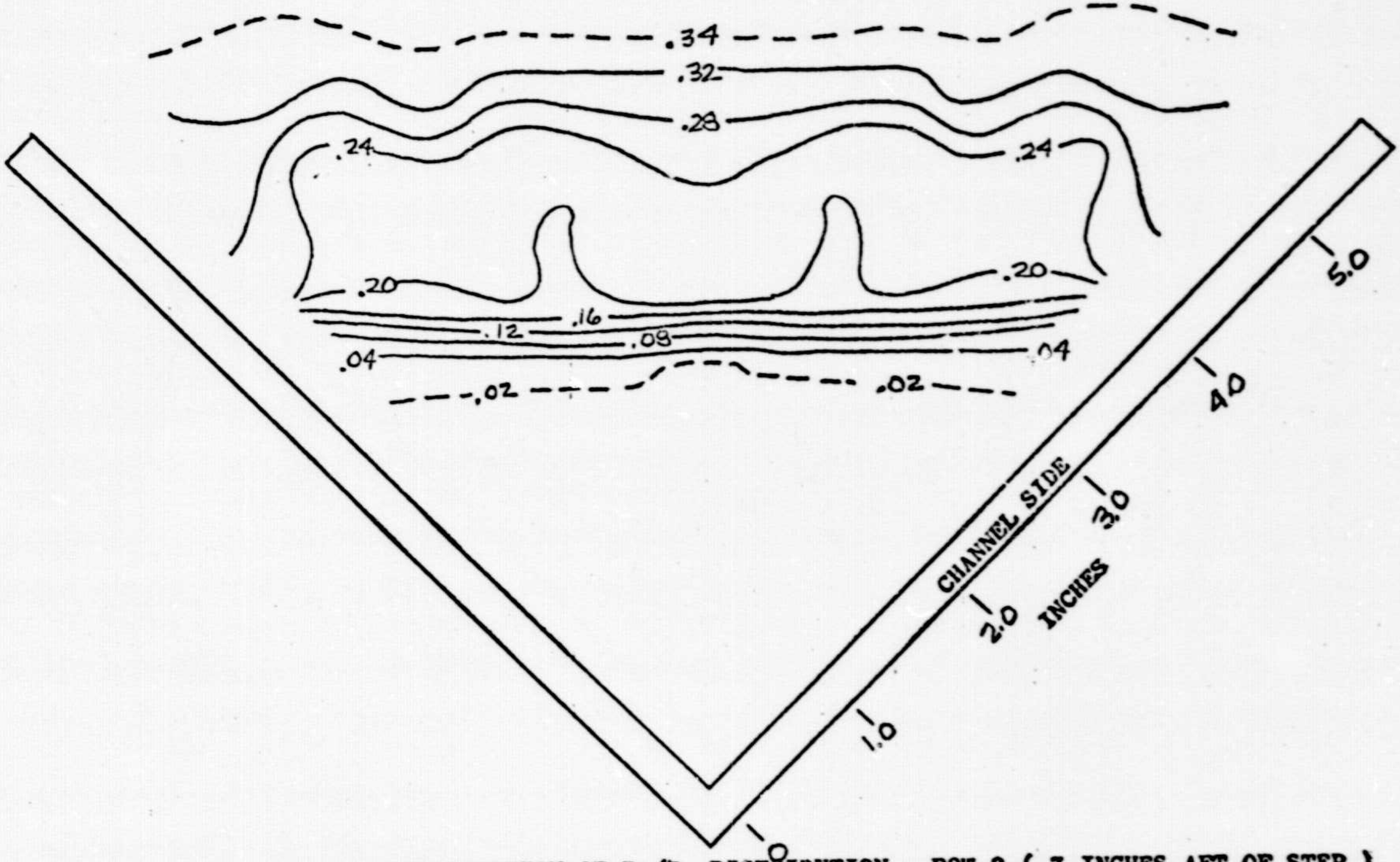
P/P'₀ SURFACE DISTRIBUTION - MACH 2.97 - 0° TILT

CHANNEL AT 0° TILT

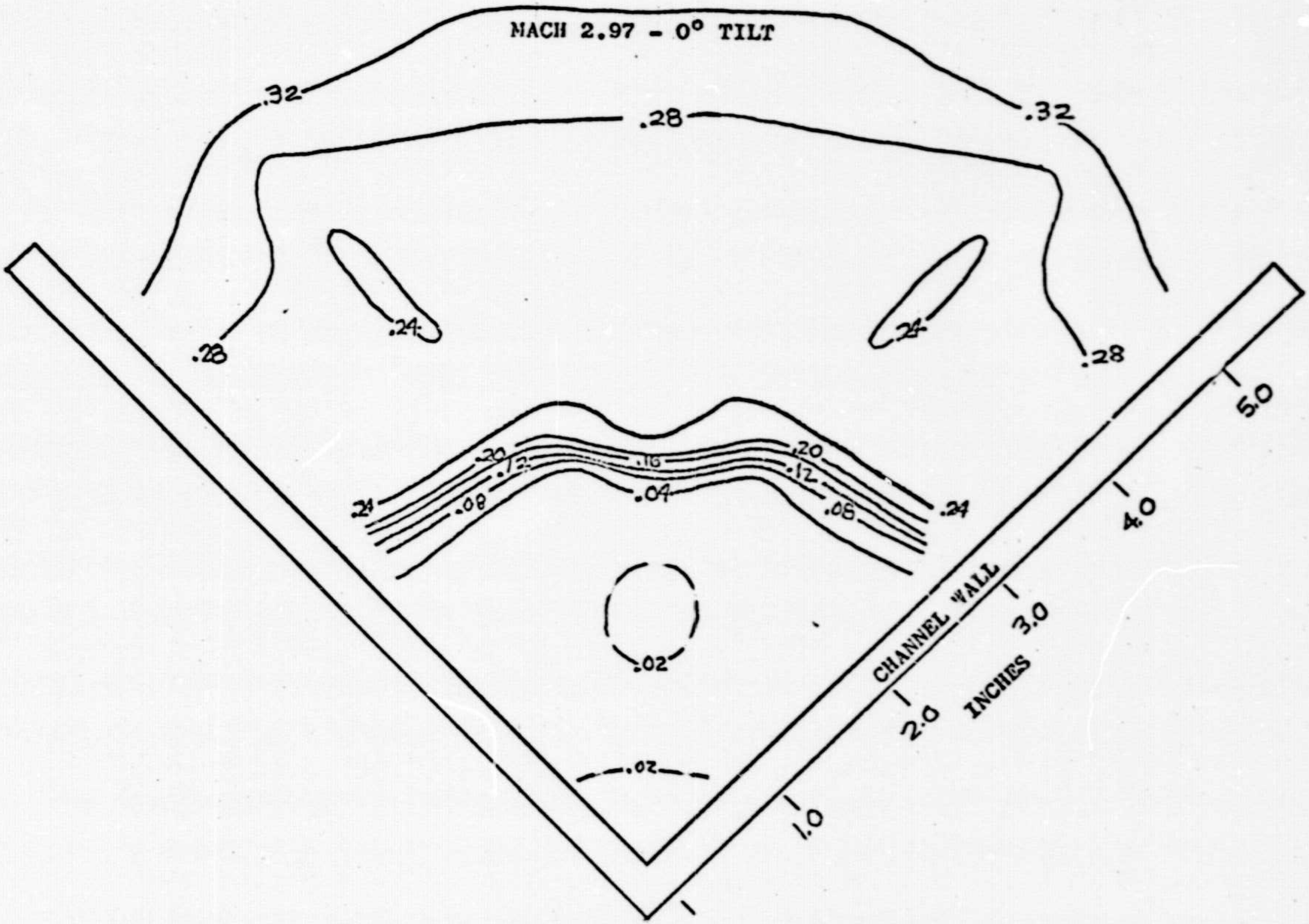


MACH 2.97 - P_t/P_o DISTRIBUTION - VERTICAL CENTER LINE PLANE THROUGH CHANNEL

MACH 2.97 - 0° TILT

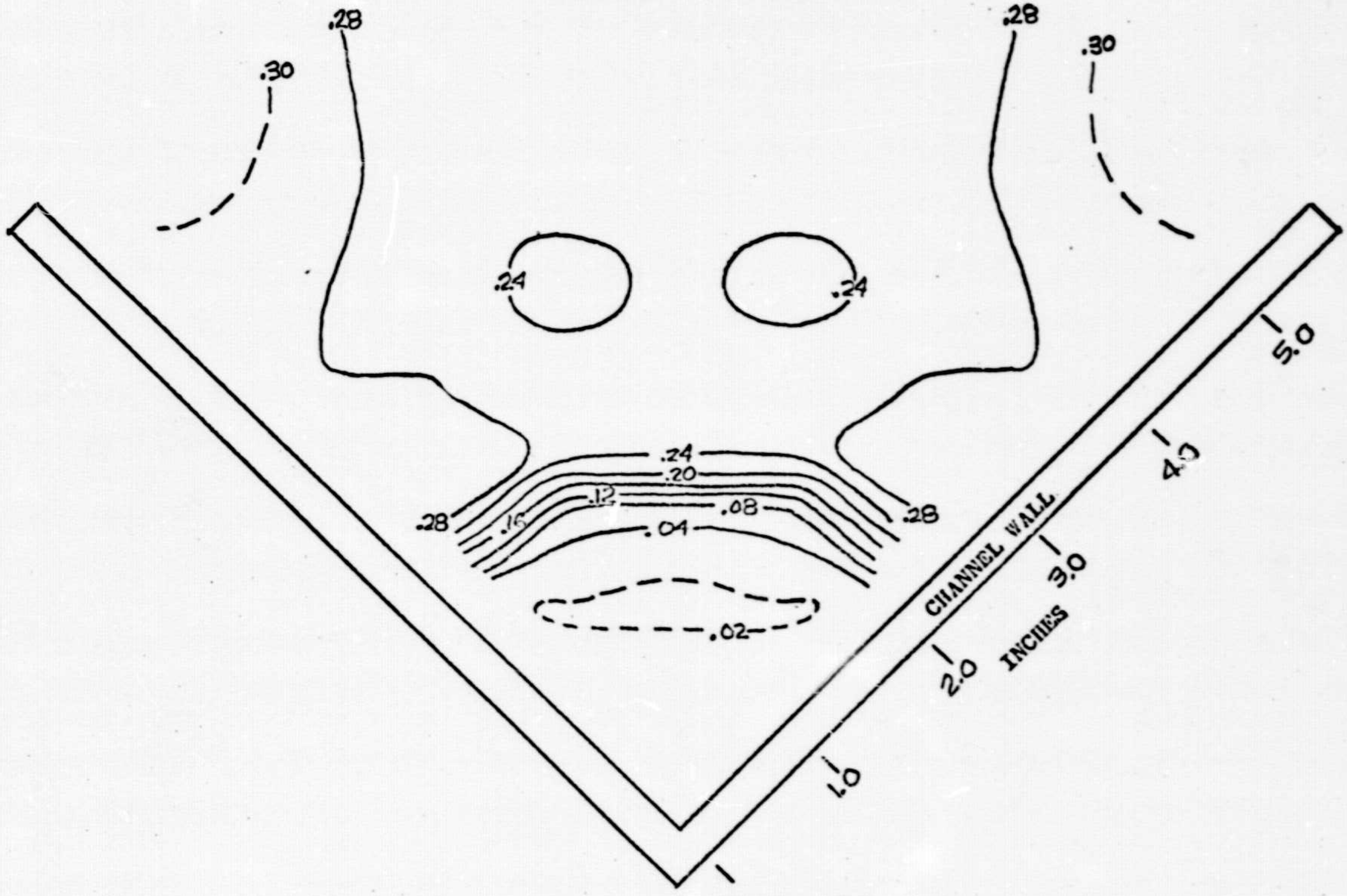


CROSS SECTION OF P_t/P_o DISTRIBUTION - ROW 2 (3 INCHES AFT OF STEP)



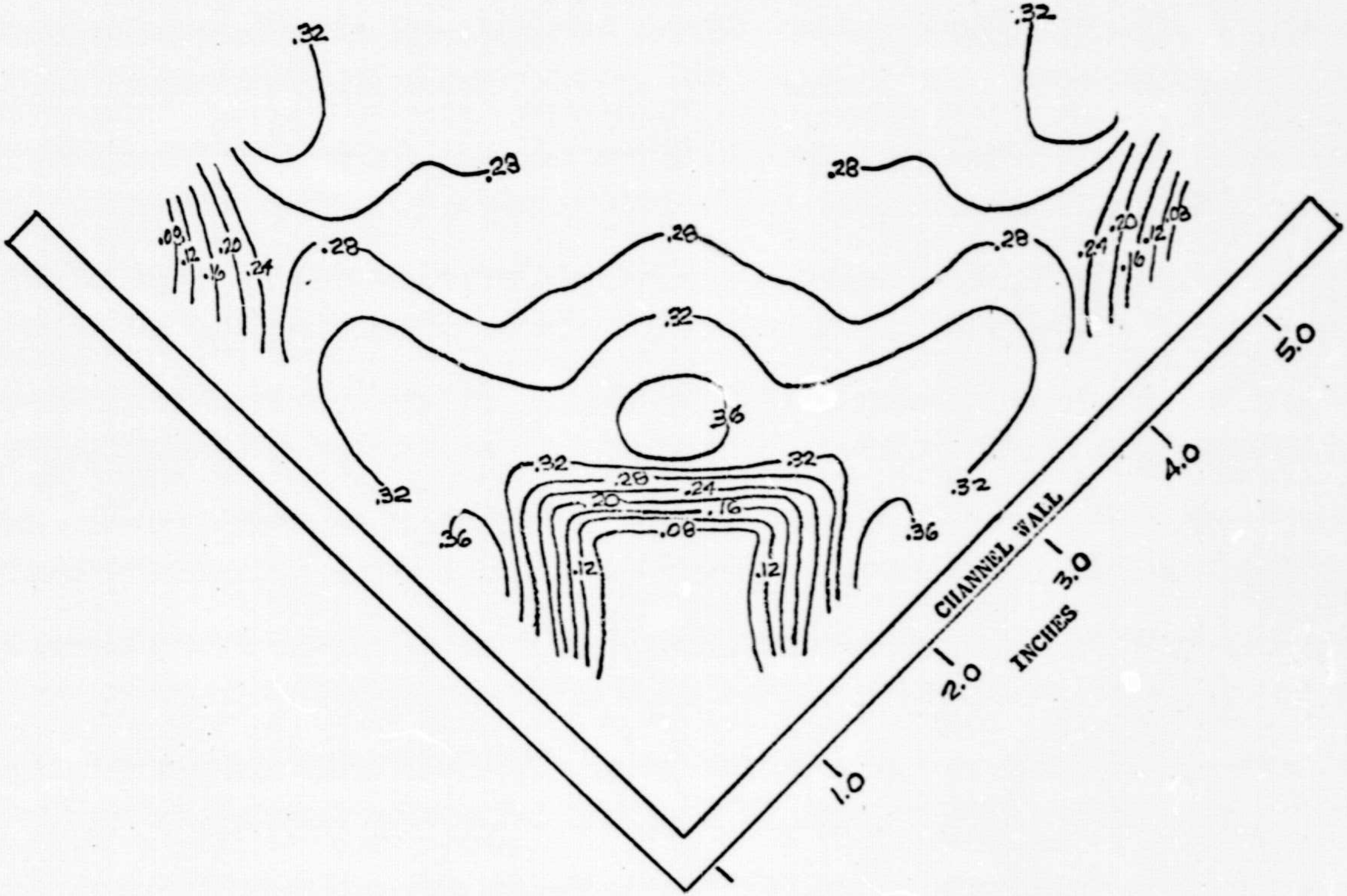
CROSS SECTION OF P_t/P_o DISTRIBUTION - ROW 3 (6 INCHES AFT OF STEP)

MACH 2.97 - 0° TILT



CROSS SECTION OF P_t/P_o DISTRIBUTION - ROW 4 (9 INCHES AFT OF STEP)

MACH 2.97 - 0° TILT



CROSS SECTION OF P_t/P_o DISTRIBUTION - ROW 5 (12 INCHES AFT OF STEP)